Science on the International Space Station: Stepping Stones for Exploration

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14 ISS Expeditions Completed
Over 6 years of active human presence

Introduction to ISS

ISS Percent Complete by Mass

U.S. RESEARCH CREW TIME

L-1 Month Most Recent to Launch
OOS (or IDRD until OOS release)

Minimum Requirement
Actuals Provided -- includes all scheduled, task-list, and Saturday Science hours

Legend
- Minimum Requirement
- Actuals Provided
- Green
- Yellow
- Red

Assembly complete
Completing
6/1/2001
Height: 114 ft
Weight: 863,688 lbs
Volume: 33,125 cubic feet

International Space Station Program Office
www.nasa.gov/press/"

February 12, 2007

NOTES:

* The mass reduction at the 3R timeframe is due to an undocked ATV.
* The mass reduction at the 1J/A timeframe is due to an undocked ATV.
* The mass reduction at the 13A.1 timeframe is due to an undocked Progress.
* The mass totals are represented from Shuttle flight to Shuttle flight and include all visiting vehicles.
* Based on (SSP 50110) Multi-Increment Manifest Rev H

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Research Outfitting

ISS Research Accommodations Status

ISS Major Pressurized Science Outfitting

ISS Major External Science Outfitting

Nine NASA Research Racks On Orbit

Planned NASA Research Facilities

NASA pressurized payload rack facilities awaiting launch
**Planned NASA Research Facilities**

- **NASA pressurized payload rack** facilities awaiting launch
  - Microgravity Science Research Rack (MSRR) (2009)
    - Facility to support ESA Microgravity Science Lab furnace
  - Fluids Integrated Rack (FIR) (2009)
    - Facility dedicated to fluid physics research, with Light Microscope Module
  - Window Observation Research Facility (WORF) (2009)
    - Facility to support visual and multispectral remote sensing using Lab Optical Window
  - Muscle Atrophy Research Exercise System (MARES) (2009)
    - Facility for musculoskeletal, biomechanical, neuromuscular and neurological physiology measurements

**European Space Agency (ESA)**

- **Research racks launched in Columbus**
  - European Physiology Module
    - Facility for human physiology research in neuroscience, cardiorespiratory biology and muscle metabolism
  - Fluid Science Lab
    - Multi-user facility for fluid physics research
  - Biolab
    - Facility for cell culture, tissue, microorganisms, small plants and animals research, including fluorescence, incubator, microscope
  - European Drawer Rack
    - Provides for mid-deck-class experiment and storage
  - European Transport Carrier
    - Storage and transportation rack for experiments

**Japanese Aerospace Exploration Agency (JAXA)**

- **Research racks launched with pressurized elements or later on HTV**
  - Ryutai (Fluids) Saibo (2008)
    - Fluid physics and research, plant growth research, solar cells, remote sensing, image processing unit
  - Sailor (2008)
    - Cell biology facility, contains cell biology experiment facility, including microscope, centrifuge
  - Kobaira (2009)
    - Gradient Heating Furnace for materials processing research

**Kibo**

- **External payloads launched with JEM-EF or later on HTV**
  - Space Environment Data Acquisition (SEDA) (2009)
    - Monitor neutrons, plasma, atomic oxygen, and heavy ions
  - Monitor All-sky X-ray Image (MAXI) (2009)
    - Monitor All-sky X-ray Image (MAXI) (2009)
  - Superconducting Sub millimeter-wave Limb-Emission Radiometer (SMILES) (2009)
    - Demonstrate sub-millimeter sensor technology and conduct sub-millimeter limb-emission sounding of the atmosphere
  - Demonstrate sub-millimeter observation of trace gases in the stratosphere

The NASA Authorization act of 2005 designated the U.S. facilities and resources on the ISS as a “national laboratory” (Public Law 109-155, Sec. 507)

- Directed NASA to develop a plan to “increase the utilization of the ISS by other Federal entities and the private sector…”
- As the Nation’s newest national laboratory, the ISS will further strengthen relationships among NASA, other Federal entities, and private sector leaders in the pursuit of national priorities for the advancement of science, technology, engineering, and mathematics.
- The ISS National Laboratory will also open new paths for the exploration and economic development of Space.
- Opportunity to expand the US economy in space-based research, applications and operations.
- Unique and highly visible national asset with surplus capacity available for a wide spectrum of applications
- NASA will continue to cover cost of operating and maintaining the ISS, and is highly motivated to work with other agencies and organizations to pursue applications.
ISS Event Horizon for National Laboratory Implementation

Calendar Year

<table>
<thead>
<tr>
<th>Year</th>
<th>National Lab Plan</th>
<th>Assembly Complete</th>
<th>Shuttle Retirement</th>
<th>Service Life Extension Decision</th>
<th>Current Service Life End</th>
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Preparatory Window

Assembly Operations

Service Operations in 4 Years

“Early utilization” on ISS

- Science completed during assembly
  - Early returns during the course of assembly
  - Takes advantage of assembly delays, extra crew time
  - Means that every crewmember on ISS can be a subject for human research experiments
  - More human experiments and larger sample sizes over the life of ISS
- Provides information on the potential uses of ISS after assembly is complete

Expedition 14 Research Accomplishments
(September 2006 – April 2007)

- Expedition 14
  - 34 U.S.-integrated investigations
  - 11 new investigations
  - 8 completed investigations
  - 139 scientists
- Expeditions 0-14
  - 112 U.S.-integrated investigations
  - 80 completed investigations
  - 373 scientists

Expedition 15 Research Accomplishments
(Oct 2007 – Apr 2008, data as of May 2007)

- Expedition 15 Plans
  - 38 U.S.-integrated investigations
  - 11 new investigations
  - 7 reserve investigation
  - 139 scientists

Science Accomplishments on ISS

Expedition 14 Research Accomplishments
(September 2006 – April 2007)

Expedition 15 Plans

Expedition 15

Science Accomplishments on ISS

Expedition 14

Expedition 15

Human Research and Countermeasure Development for Exploration
Technology Development
Physical and Biological Sciences in Microgravity
Observing the Earth and Educational Activities
U.S. Investigations on ISS


Outside U.S.: 39
ISS Educational Accomplishments

- K-12 Student participation on ISS 2000-2006
- 66,000 students in inquiry based learning with ISS data
- 800,000 students with classroom versions of ISS experiments
- 31 million had the opportunity to see telecasts from ISS
- 470 undergraduate students
- 251 graduate and postdoctoral students

The Vision for Space Exploration and The ISS National Laboratory

On January 14, 2004, the focus of NASA research on ISS was fundamentally changed with President Bush’s Vision for U.S. Space Exploration.

NEW ISS Focus for NASA
- Astronaut health and countermeasure development to protect crews from the space environment during long duration voyages
- Testing research and technology developments for future exploration missions
- Developing and validating operational procedures for long-duration space missions

The Vision for Space Exploration

On January 14, 2004, the focus of NASA research on ISS was fundamentally changed with President Bush’s Vision for U.S. Space Exploration.

NEW ISS Focus for NASA
- ISS Focus for NASA before Exploration Vision: Diverse, multi-discipline research
  - Human Life Sciences
  - Biological Sciences
  - Materials Science
  - Fluids Science
  - Combustion Science
  - And all other sciences!

ISS Medical Project
Experiments on ISS can address:

**SPACE SYSTEM**
- Advanced life support
- Exercise systems
- Clinical capabilities
- Radiation
- Dust

**HUMAN SYSTEM**
- Integrated physiology
- Cardiovascular
- Bone & Muscle
- Neurovestibular
- Food and nutrition
- Immunology & infection
- Human behavior & performance
ISS Medical Project

- ISSMP has been developed to maximize the utilization of ISS to obtain solutions to the human health and performance problems and the associated mission risks of exploration class missions.
- Complete programmatic review with medical operations (space medicine/flight surgeons) to identify:
  - Evidence base on risks
  - Gap analysis
  - Rapid implementation of key studies to optimize human research return

Disciplines Represented in early ISS Research

- Human Research
- Cell Biology and Biotechnology
- Plant Biology
- Physical Sciences
- Technology Development
- Environmental Monitoring
- Earth Observation
- Education

NASA mission-driven Research and the National Laboratory

- ISS for Exploration (NASA mission)
  - Human Research for Exploration
  - Exploration Technology Development
  - Space Operations Improvement
- ISS National Laboratory (Missions of many agencies and organizations)
  - Basic physiology
  - Biology and Biotechnology
  - Physical Sciences
  - Education
- Bridging work:
  - Microgravity Set-aside
  - Education
  - Earth Observations